REDMOND FIRE DEPARTMENT
STANDPIPE FLOW TEST GUIDELINES

A functional flow test shall be performed at your expense to prove the standpipe design as required for normal system acceptance procedures found in Chapter 9 of NFPA 14.

I. REQUEST FOR TEST

The contractor shall request this test in writing at least 3 weeks in advance. The letter shall state whether or not the contractor will supply a private rated pumper or request the use of a Redmond Fire Department pumper and state that the appropriate party will accept the equipment expenses necessary to have the pumper and its crew of two fire department personnel at the test (see below) for a minimum of 2 hours. The following are excerpts from Table F of Resolution No. 1073 (fees last updated on 1/1/04):

Labor Costs Per Hour Including Overhead	
Labor Category	Overtime Rate
Fire suppression and Other Services	$73.83

Vehicle Equipment Costs Per Hour Including Overhead		
Vehicle	Active Duty Hourly Rate	Mileage Rate
Pumper Truck	$115.66	$.66/mile

Your request must include an acceptable liability waiver for the Fire Department and must be submitted by the company that will be billed for the services.

II. EQUIPMENT

The contractor shall provide the following equipment to perform single and multiple hose connection flow tests as necessary:

A. Communications equipment for personnel at each gauge. <u>NO Nextel style phones</u>
B. Enough personnel to man each gauge and to move equipment as necessary
C. Liquid filled gauges (0-300 psi)
D. Pitot gauges
E. Hose and solid bore nozzles with verifiable coefficient. Nozzle size shall range from 1-1/8” to 1-1/2” to obtain pitot readings between 20-30 psi near the desired flows. Readings within this range will result in a more accurate test.

III. NOTIFICATION

The contractor shall also notify the following City of Redmond agencies and/or personnel of this test at least 3 weeks in advance via telephone.

A. The City Public Works Engineering Construction Division (Site Inspection), (425) 556-2723.
B. Dave Reese, Public Works Water Utility Maintenance Division, (425) 556-2819.

Your notification must contain the date, start time, anticipated duration and estimated total gallons to be flowed during the test. These agencies/personnel may have additional requirements for water use reimbursement and test water runoff mitigation that must be met to conduct the test.

IV. SET-UP / PREPARATION

The contractor shall take the following steps prior to the arrival of the fire inspector:

A. The contractor shall connect pressure gauges to:

1. Fire department connection
2. Base of system riser
3. Most remote outlets. One for each outlet that the design is required to flow.

    a. Most remote standpipe outlet on most remote standpipe riser
    b. Second most remote standpipe outlet on most remote standpipe riser
    c. Most remote standpipe outlet on second most remote standpipe riser (if applicable)
    d. Most remote standpipe outlet on third most remote standpipe riser (if applicable)

B. Connect hose with nozzle to the standpipe outlets that the design is required to flow:

1. Most hydraulically remote standpipe outlet on most remote standpipe riser.
2. Second most hydraulically remote standpipe outlet on most remote standpipe outlet.
3. Most hydraulically remote standpipe outlet on second most remote standpipe riser (if applicable).
4. Most hydraulically remote standpipe outlet on third most remote standpipe riser (if applicable).

C. Any mitigation required by other City of Redmond Departments/Divisions (e.g. water treatment, water impound, etc.)

Extend sufficient hose to a discharge area that will drain into an approved detention area.

V. FLOW PROCEDURE

A. A private rated pumper or Redmond Fire Department pumper will be connected to the FDC. Two 3-1/2" supply lines from the pumper to the FDC shall be used when the standpipe system is designed to flow at a rate exceeding 750 gpm.

B. The flow test will consist of the following:
Test #1

The most remote standpipe outlet on the most remote standpipe riser shall be opened. Pressure readings will be taken for the following pressures (minimum) at the FDC provided by a pumper:

1. City pressure
2. 150 psi
3. 165 psi
4. 175 psi

Pressure readings will be taken at the base of the most remote standpipe riser, standpipe outlet being flowed, and at the point of discharge. A pitot gauge will be used to measure the pressures at the point of discharge.

Test #2

All standpipe outlets with hose connected to them shall be opened simultaneously. Pressure readings will be taken for the following pressures (minimum) at the FDC provided by a pumper:

1. City pressure
2. 150 psi
2. 165 psi
3. 175 psi

Pressure readings will be taken at the base of each riser and at each standpipe outlet being flowed, and at all points of discharge. A pitot gauge will be used to measure the pressures at the points of discharge.

These pressure readings will be recorded on the "Standpipe Flow Test Record Form" (see attached)

VI. FOLLOW UP DOCUMENTATION

A. At the completion of the flow test, the contractor shall forward the "Standpipe Flow Test Record Form" to the designer of the standpipe system.

B. The standpipe designer will use the data from the "Standpipe Flow Test Record Form" to determine if actual flow rates and pressures meet or exceed design flow rates and pressures. The designer shall use the data from the test to determine the input pressure required at the FDC to provide the required flows and pressures at the most remote hose valves as follows:

1. 250 gpm @ 100 psi and 320 gpm @ 110 psi (Redmond Fire Department Standard) at most remote outlet on most remote standpipe riser.
2. 250 gpm @ 100 psi at second most remote outlet on most remote standpipe riser.
3. 250 gpm @ 100 psi at most remote outlet on each additional standpipe riser, with the total not to exceed 1250 gpm in a non-sprinkled building and 1000 gpm in a sprinkled building.

NOTE: Redmond Fire Department Standards require a minimum pumping pressure of 150 psi at all FDC's.

C. The standpipe designer shall provide the Redmond Fire Department with a letter stating that the system meets Redmond Fire Department and NFPA standards for flow and pressure at the outlets noted above. This letter shall include the following information:

1. Determine the pressure *difference* (P_d) between the pressures at the discharge *valve* (P_v) and the pressure reading at the FDC inlet (P_s). $P_d = P_s – P_v$. Tabulate these results with their corresponding flows.

2. If standpipe pressures are taken from a valve away from the flow valve, such as the floor above or below, they should be taken from the standpipe that is being flowed. Pressures then need to be adjusted for elevation and friction loss through the pipe between the pressure gauge outlet and the flow outlet at the determined flow/pitot reading.

$P_a = P_t - (E_v \times .433) - P_f$

Where P_a = Adjusted pressure
P_t = Test pressure (recorded)
E_v = Elevation difference in feet
P_f = Pressure due to friction loss NFPA 13, section 6-4.2.1

$P_f = L \times \frac{4.52Q^{1.85}}{C^{1.85} d^{4.87}}$

Where L = Length of pipe + equivalent length of fittings

3. Include a static point that represents the elevation difference in psi between the FDC and the flow valve at 0 gpm (P_{d0}).

4. On a graph, approximate a “best fit” line from the static point through the data points. From this line determine the approximate pressure drops through the system at the desired 320gpm and 250 gpm at the most hydraulically remote standpipe outlets.

5. The desired pumping pressures are obtained by adding the desired outlet pressures of 110 psi for 320 gpm and 100 psi for 250 gpm to the pressure difference obtained from the graph.

6. Provide a table of “Actual vs. Calculated Pressures” for all fire department connections (see page 7).

TEST # 2

STANDPIPE FLOW TEST RECORD FORM

Project Name: ____________________ **Inspector:** ________________

Site Address: _____________________ Date: ____________________

Contractor: ______________________

TEST #1

OUTLET #1 – MOST REMOTE STANDPIPE

SIZE OF ORIFICE	PRESSURE AT FDC	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
	(City PSI)			
	150 PSI			
	165 PSI			
	175 PSI			

TEST #2

CITY PRESSURE

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1				
2				
3				
4				

150 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1				
2				
3				
4				

165 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1				
2				
3				
4				

175 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1				
2				
3				
4				

ACTUAL VS. CALCULATED PRESSURES

LOCATION OF FDC	ACTUAL PRESSURES		CALC. PRESSURES		SIGN PRESSURE
	@ 250 gpm	@ 320 gpm	@ 320 gpm	@ 250 gpm	

* Pressures are based on providing 320 gpm at 110 psi and 250 gpm at 100 psi at the most remote hose valve for standpipe systems, and Redmond Fire Department's minimum pumping pressure of 150 psi for all FDC's.

EXAMPLE
FOLLOW UP DOCUMENTATION
Test #1 - Flow from most remote standpipe outlet only

TEST #1
OUTLET #1 – MOST REMOTE STANDPIPE

SIZE OF ORIFICE	PRESSURE AT FDC	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1-1/2"	**(City PSI)** 90	100	74	32
1-1/2"	150 PSI	146	80	66
1-1/2"	165 PSI	158	86	72
1-1/2"	175 PSI	166	92	78

1. Based on the readings from the first test, we must first calculate the flow in gpm from the following formula:

   $Q = 29.83cd^2\sqrt{p}$

   Where Q = Flow in gpm
   c = Discharge coefficient
   d = Diameter of discharge orifice
   p = Pitot pressure

   The discharge coefficient for the 1-1/2" nozzle used for this test is .95
   A pitot reading of **32 psi** through a 1-1/2" nozzle results in a flow of **361 gpm**.
   A pitot reading of **66 psi** through a 1-1/2" nozzle results in a flow of **518 gpm**.
   A pitot reading of **72 psi** through a 1-1/2" nozzle results in a flow of **541 gpm**.
   A pitot reading of **78 psi** through a 1-1/2" nozzle results in a flow of **563 gpm**.

2. The pressure difference between the pressures at the discharge valve and the FDC inlet are:

   P_{d1} = 90 psi – 38 psi = **52 psi @ 361 gpm**
   P_{d2} = 150 psi – 80 psi = **70 psi @ 518 gpm**
   Pd3 = 165 – 86 psi = **79 psi @ 541 gpm**
   Pd4 = 175 – 92 psi = **83 psi @ 563 gpm**

3. The static point P_{d0} = 68.5' x 0.433 = **30 psi at 0 gpm**.
4. See attached line graph with these points. From this graph, it is determined that the pressure difference at 250 gpm is 41 psi and at 320 gpm is 48 psi.
5. The pressure needed at the FDC to obtain 250 gpm at 100 psi at the outlet is:
   P_{250} = 100 psi + 41 psi = **141 psi**

   And, the pressure needed at the FDC to obtain 320 gpm at 110 psi at the outlet is:

   P_{320} = 110 psi + 48 psi = **158 psi**

TEST # 2 – Flow from most remote and second most remote outlets of most remote riser and most remote outlet of second most remote riser simultaneously.

CITY PRESSURE

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1		60	30	14
2		60	31	14
3		60	46	18
4		60	50	20

150 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1		135	62	45
2		135	65	47
3		135	78	54
4		135	86	42

165 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1		150	72	55
2		150	70	57
3		150	88	64
4		150	95	52

175 PSI @ FDC

OUTLET #	LOCATION	PRESSURE AT BASE OF RISER	PRESSURE AT STANDPIPE OUTLET	PRESSURE AT PITOT
1		150	72	60
2		150	85	62
3		150	95	69
4		150	107	57

* Note: Based on site conditions flow test

1. As in test #1, we must first calculate the flow in gpm for the pitot reading recorded during the test from the formula above. The discharge coefficient is the same as for test #1 (.95).

   A pitot reading of **14 psi** through a 1-1/2" nozzle results in a flow of **239 gpm**.
   A pitot reading of **20 psi** through a 1-1/2" nozzle results in a flow of **285 gpm**.
   A pitot reading of **42 psi** through a 1-1/2" nozzle results in a flow of **413 gpm**.
   A pitot reading of **45 psi** through a 1-1/2" nozzle results in a flow of **428 gpm**.
   A pitot reading of **47 psi** through a 1-1/2" nozzle results in a flow of **437 gpm**.
   A pitot reading of **52 psi** through a 1-1/2" nozzle results in a flow of **460 gpm**.
   A pitot reading of **54 psi** through a 1-1/2" nozzle results in a flow of **468 gpm**.
   A pitot reading of **55 psi** through a 1-1/2" nozzle results in a flow of **473 gpm**.
   A pitot reading of **57 psi** through a 1-1/2" nozzle results in a flow of **482 gpm**.
   A pitot reading of **60 psi** through a 1-1/2" nozzle results in a flow of **494 gpm**.
   A pitot reading of **62 psi** through a 1-1/2" nozzle results in a flow of **502 gpm**.
   A pitot reading of **64 psi** through a 1-1/2" nozzle results in a flow of **510 gpm**.
   A pitot reading of **69 psi** through a 1-1/2" nozzle results in a flow of **530 gpm**.

2. The pressure difference between the pressures at the discharge valve and the FDC inlet are:

   <u>OUTLET #1 – Most remote riser</u>

   P_{d1} = 90 psi – 30 psi = **60 psi @ 239 gpm**
   P_{d2} = 150 psi – 60 psi = **90 psi @ 428gpm**
   P_{d3} = 165 psi – 68 psi = **97 psi @ 473 gpm**
   P_{d4} = 175 psi – 72 psi = **103 psi @ 494 gpm**

   <u>OUTLET #2 – Most remote riser</u>

   P_{d1} = 90 psi – 31 psi = **59 psi @ 239 gpm**
   P_{d2} = 150 psi – 65 psi = **85 psi @ 437 gpm**
   P_{d3} = 165 psi – 70 psi = **95 psi @ 482 gpm**
   P_{d4} = 175 psi – 75 psi = **100 psi @ 502 gpm**

OUTLET #3 – Second most remote riser

P_{d1} = 90 psi – 46 psi = **44 psi @ 271 gpm**
P_{d2} = 150 psi – 78 psi = **72 psi @ 468 gpm**
P_{d3} = 165 psi – 88 psi = **77 psi @ 510 gpm**
P_{d4} = 175 psi – 95 psi = **80 psi @ 530 gpm**

OUTLET #4 – Third most remote riser

P_{d1} = 90 psi – 50 psi = **40 psi @ 285 gpm**
P_{d2} = 150 psi – 86 psi = **64 psi @ 413 gpm**
P_{d3} = 165 psi – 97 psi = **68 psi @ 460 gpm**
P_{d4} = 175 psi – 105 psi = **70 psi @ 482 gpm**

TOTAL SYSTEM FLOW

P_{d1} = 90 psi – 30 psi = **60 psi @ 979 gpm**
P_{d2} = 150 psi – 60 psi = **90 psi @ 1746 gpm**
P_{d3} = 165 psi – 68 psi = **97 psi @ 1925 gpm**
P_{d4} = 175 psi – 72 psi = **103 psi @ 2008 gpm**

NOTE: Graph for total system flow is the total gpms flowing from all four outlets based on the pressures at the most remote outlet.

3. The static point is the same as that for test #1 above (**30 psi @ 0gpm**) for outlets 1, 3,and 4. The static point for outlet # 2 is P_{d0} = 58.5' X 0.433 = **25 psi @ 0 gpm**.

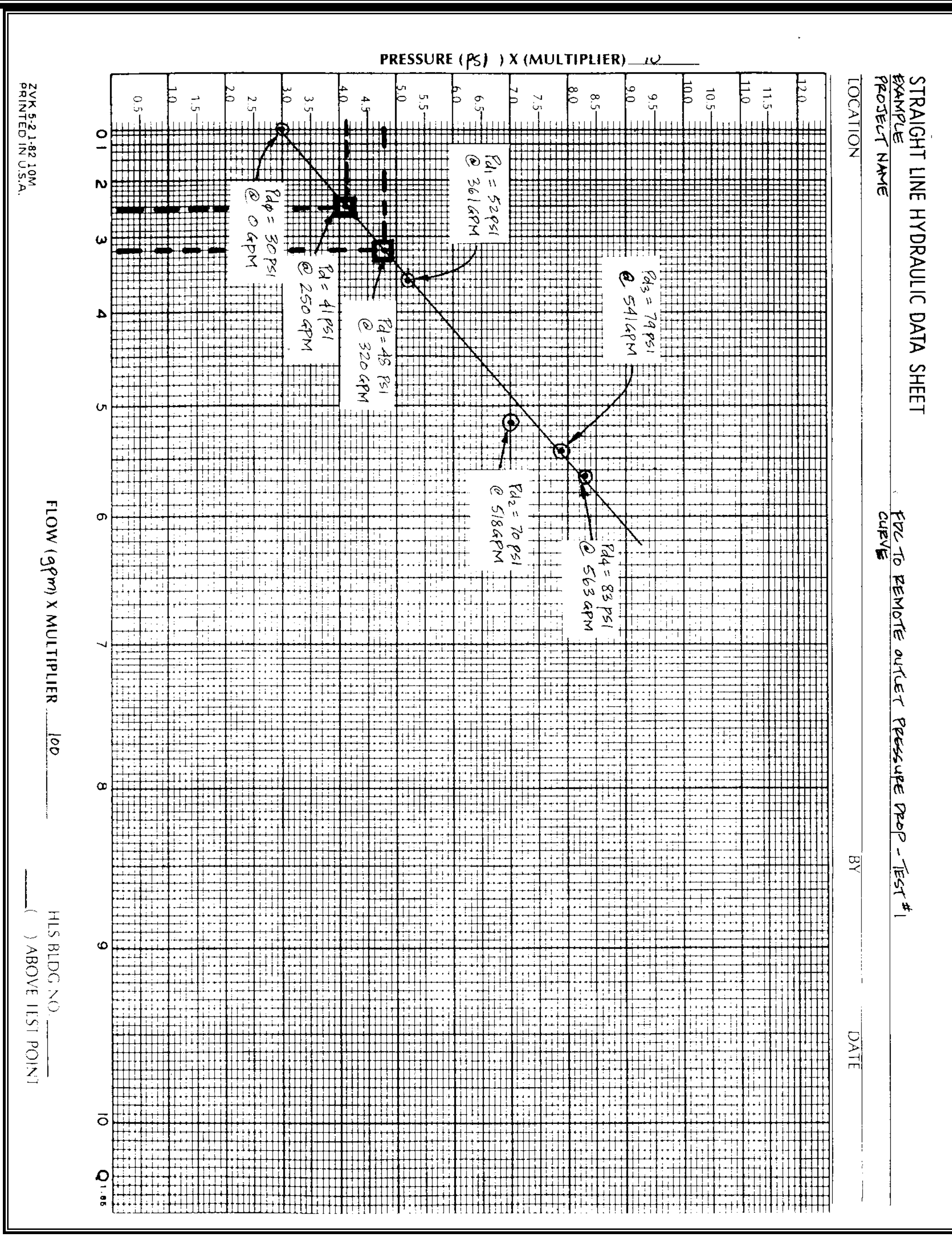
4. See attached line graphs with these points. From these graphs, it is determined that the pressure difference at 250 gpm for the outlets tested are:
   Outlet # 1 = **52 psi**
   Outlet # 2 = **46 psi**
   Outlet # 3 = **42 psi**
   Outlet # 4 = **42 psi**

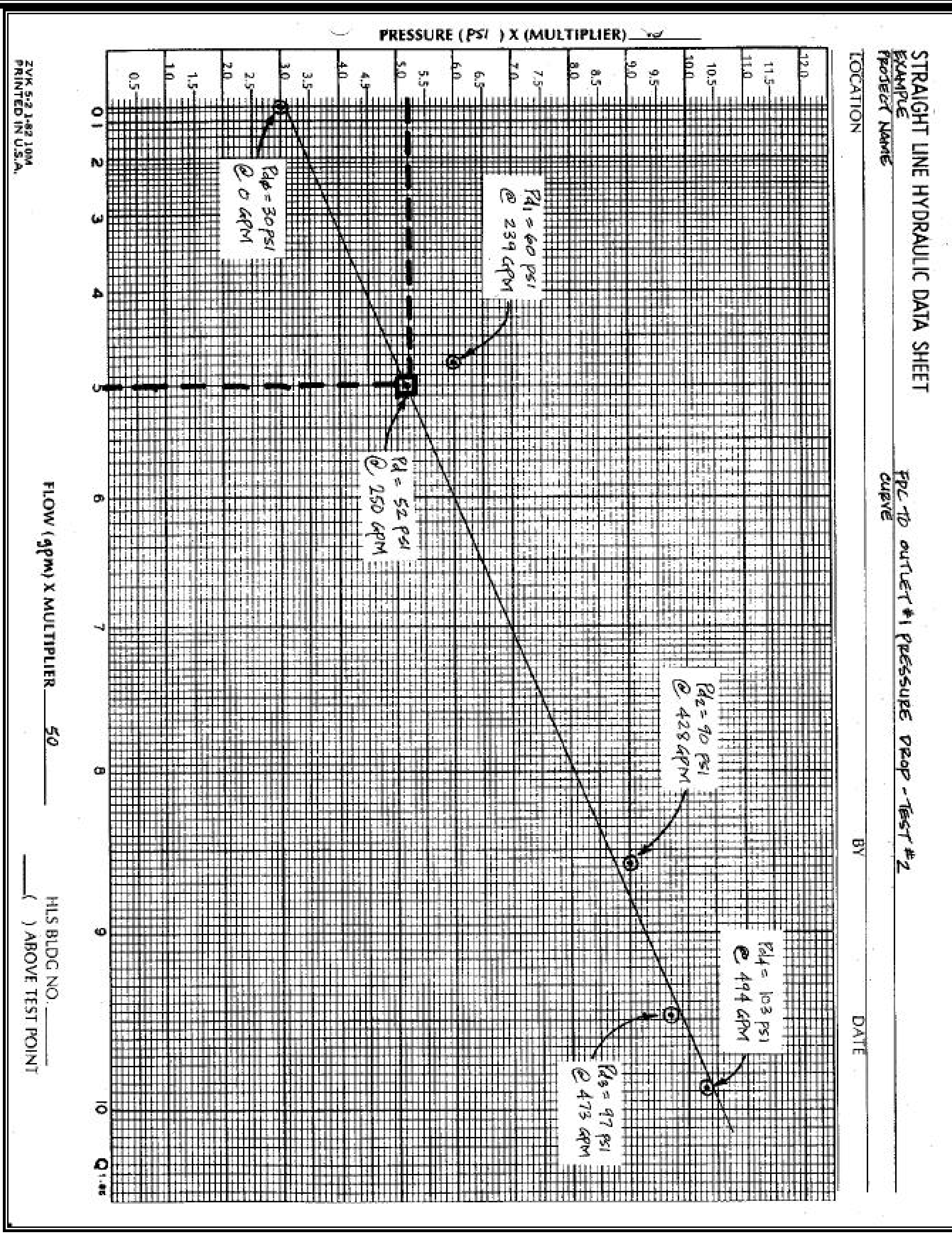
5. The pressure needed at the FDC to obtain 250 gpm at 100 psi at each outlet is
   $P_{outlet\ \#1}$ = 100 psi + 52 psi = **152 psi**
   $P_{outlet\ \#2}$ = 100 psi + 46 psi = **146 psi**
   $P_{outlet\ \#3}$ = 100 psi + 42 psi = **142 psi**
   $P_{outlet\ \#4}$ = 100 psi + 42 psi = **142 psi**

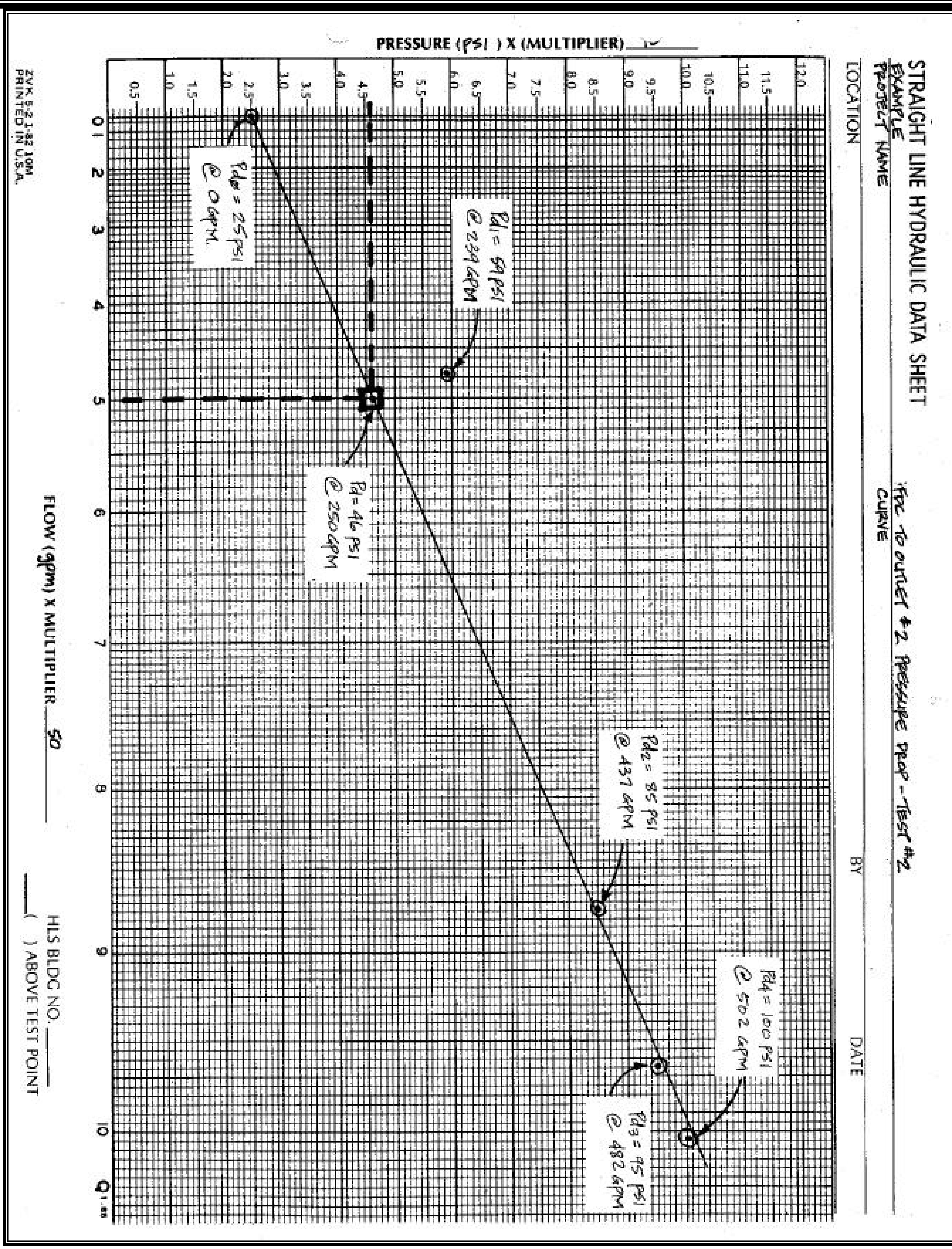
6. Based on the attached "Pressure Drop for Total System Flow – Test #2" line graph. It is determined that the pressure difference at 1000 gpm total system flow is:
   $P_{total\ flow}$ = 100 psi + 51 psi = **151 psi**

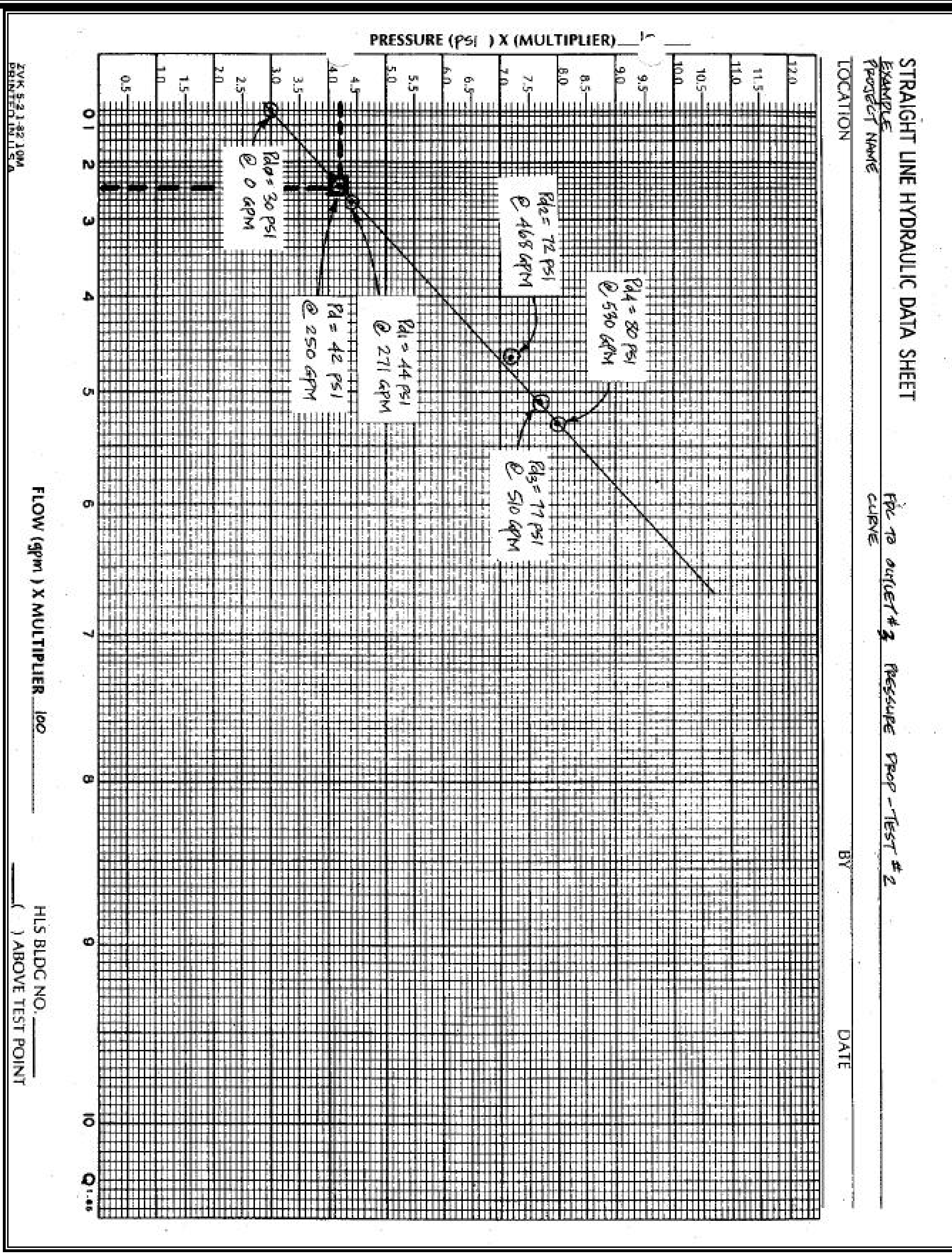
7. Based on the results of the calculations for test #1 and test #2, the minimum pressure required at the FDC is **158 psi** to meet all the following design criteria:

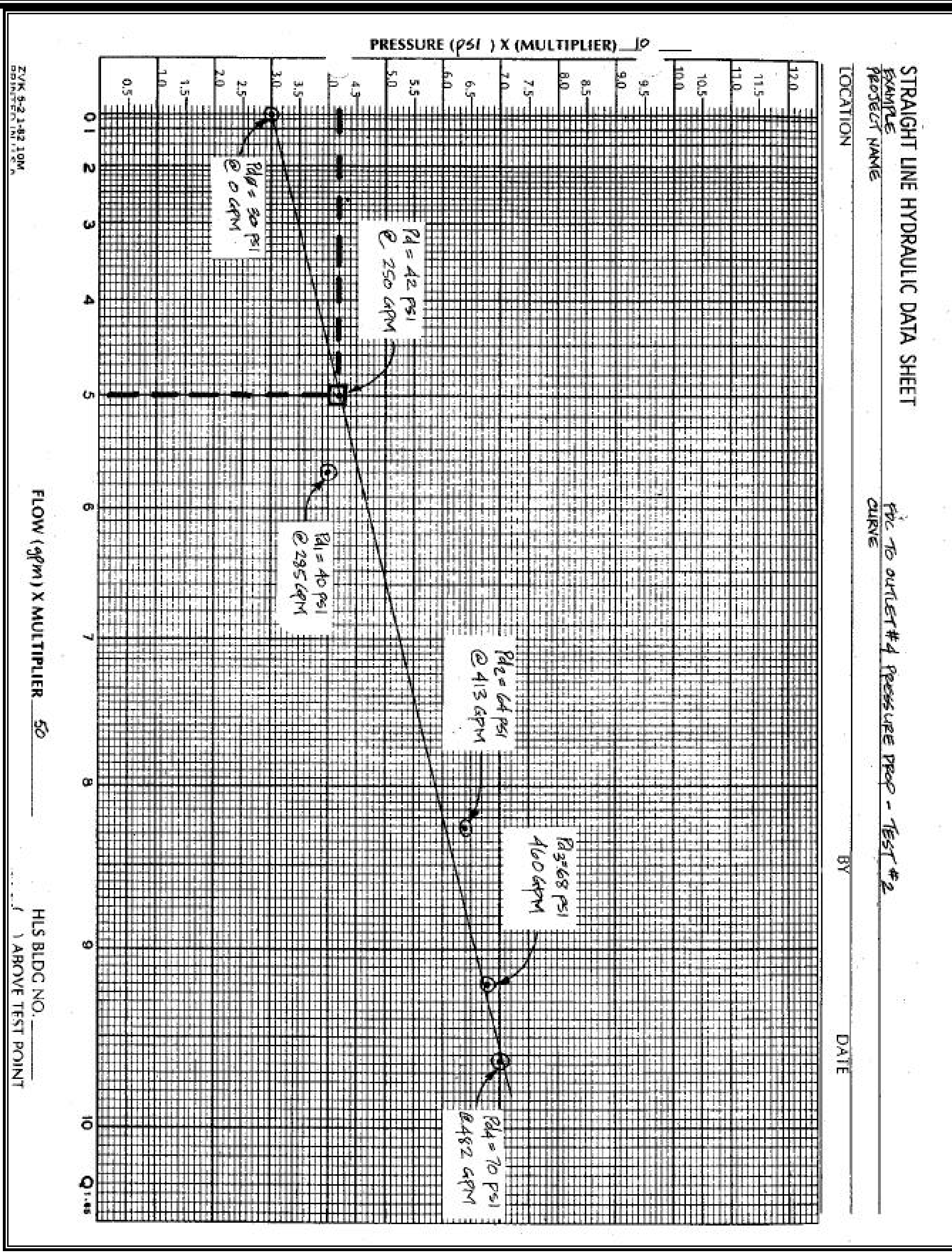
   a. 250 gpm @ 100 psi at the most remote outlet
   b. 320 gpm @ 110 psi at the most remote outlet
   c. 1000 gpm @ 100 psi total system flow

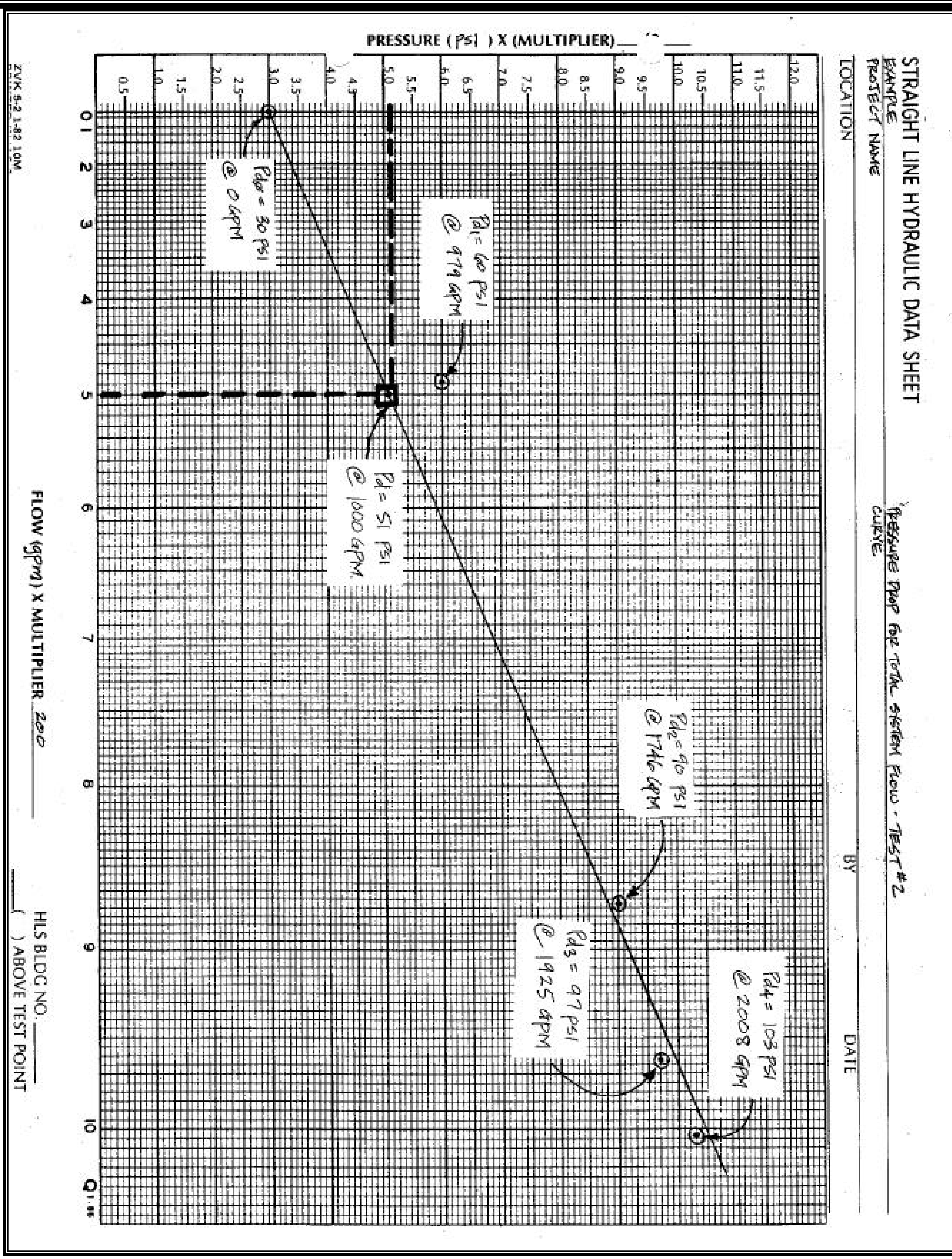

STRAIGHT LINE HYDRAULIC DATA SHEET
EXAMPLE
PROJECT NAME
LOCATION
FDC TO REMOTE OUTLET PRESSURE DROP - TEST # 1
CURVE
BY
DATE
PRESSURE (PSI)) X (MULTIPLIER) 10
FLOW (gpm) X MULTIPLIER 100
HLS BLDG NO.
( ) ABOVE TEST POINT
Pdφ = 30 PSI @ 0 GPM
Pd = 41 PSI @ 250 GPM
Pd = 45 PSI @ 320 GPM
Pd1 = 52 PSI @ 361 GPM
Pd2 = 70 PSI @ 518 GPM
Pd3 = 79 PSI @ 541 GPM
Pd4 = 83 PSI @ 563 GPM
ZVK 5-2.1-82 10M
PRINTED IN U.S.A.


STRAIGHT LINE HYDRAULIC DATA SHEET
EXAMPLE
PROJECT NAME
FDC TO OUTLET #1 PRESSURE DROP - TEST #2
CURVE
LOCATION
BY
DATE
PRESSURE (PSI) X (MULTIPLIER) 10
Pdφ = 30 PSI @ 0 GPM
Pd1 = 60 PSI @ 239 GPM
Pd = 52 PSI @ 250 GPM
Pd2 = 90 PSI @ 428 GPM
Pd3 = 97 PSI @ 473 GPM
Pd4 = 103 PSI @ 494 GPM
FLOW (gpm) X MULTIPLIER 50
HLS BLDG NO.
( ) ABOVE TEST POINT
ZVK 5-2 1-82 10M
PRINTED IN U.S.A.


STRAIGHT LINE HYDRAULIC DATA SHEET
PROJECT NAME EXAMPLE
FDC TO OUTLET #2 PRESSURE DROP - TEST #2
CURVE
LOCATION
BY
DATE
PRESSURE (PSI) X (MULTIPLIER)
Pdø = 25 PSI @ 0 GPM.
Pd1 = 59 PSI @ 239 GPM
Pd = 46 PSI @ 250 GPM
Pd2 = 85 PSI @ 437 GPM
Pd3 = 95 PSI @ 482 GPM
Pd4 = 100 PSI @ 502 GPM
FLOW (gpm) X MULTIPLIER 50
HLS BLDG NO.
( ) ABOVE TEST POINT
ZVK 5-2 1-82 10M
PRINTED IN U.S.A.


STRAIGHT LINE HYDRAULIC DATA SHEET
EXAMPLE
PROJECT NAME
LOCATION
FDC TO OUTLET #3 PRESSURE DROP – TEST #2
CURVE
BY
DATE
PRESSURE (PSI) X (MULTIPLIER)
Pdø = 30 PSI @ 0 GPM
Pd = 42 PSI @ 250 GPM
Pd1 = 44 PSI @ 271 GPM
Pd2 = 72 PSI @ 468 GPM
Pd3 = 77 PSI @ 510 GPM
Pd4 = 80 PSI @ 530 GPM
FLOW (gpm) X MULTIPLIER 100
HLS BLDG NO.
( ) ABOVE TEST POINT


STRAIGHT LINE HYDRAULIC DATA SHEET
EXAMPLE
PROJECT NAME
LOCATION
FDC TO OUTLET #4 PRESSURE PROP - TEST #2
CURVE
BY
DATE
PRESSURE (psi) X (MULTIPLIER) 10
FLOW (gpm) X MULTIPLIER 50
HLS BLDG NO.
ABOVE TEST POINT
Pdø = 30 PSI @ 0 GPM
Pd = 42 PSI @ 250 GPM
Pd1 = 40 PSI @ 285 GPM
Pd2 = 64 PSI @ 413 GPM
Pd3=68 PSI 460 GPM
Pd4 = 70 PSI @482 GPM


STRAIGHT LINE HYDRAULIC DATA SHEET
EXAMPLE
PROJECT NAME
PRESSURE DROP FOR TOTAL SYSTEM FLOW - TEST #2
CURVE
LOCATION
BY
DATE
PRESSURE (PSI) X (MULTIPLIER)
Pd0 = 30 PSI @ 0 GPM
Pd1 = 60 PSI @ 979 GPM
Pd = 51 PSI @ 1000 GPM
Pd2 = 90 PSI @ 1746 GPM
Pd3 = 97 PSI @ 1925 GPM
Pd4 = 103 PSI @ 2008 GPM
FLOW (gpm) X MULTIPLIER 200
HLS BLDG NO.
( ) ABOVE TEST POINT